



# **Optical Communications at JPL**

**Presented**

**at**

**DARPA**

**Steered Agile Laser Beam Workshop**

**March 24 -25, 1999**

**by**

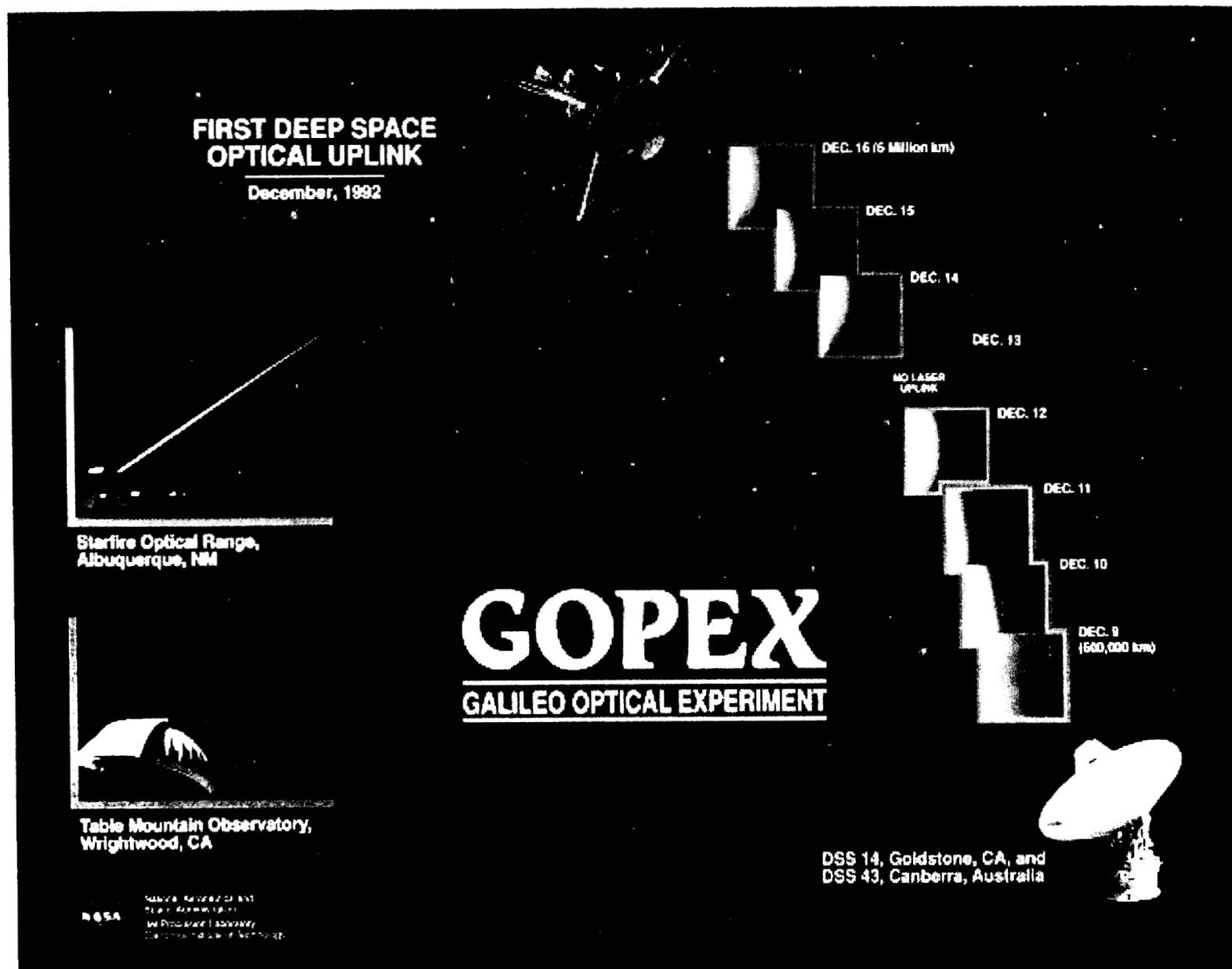
**K. E. Wilson**



# Presentation Outline

- **Optical Communications Demonstrations**
- **Laser Communications Field-tests**
  - Multi-beam Ground-to-space links
  - Horizontal Path Ground-to-ground links
- **Atmospheric Visibility Monitoring**
- **Optical Communications Demonstrator**
- **Laser Com Terminal Test Station**
  - LTES
- **Future Optical Communications Developments**
  - OCTL
  - International Space Station Demonstration
- **Summary**

# Optical Com Demonstrations



# Optical Com Demonstrations

## GOLD

### GROUND-TO-ORBIT LASER-COM DEMONSTRATION



**ETS-VI SATELLITE**

NASA provided JPL with ETS-VI data to help in pointing the telescope and ground-to-orbit laser. Satellite control commands were sent from Table Mountain to OGS 27.



Tokyo

Communications Research Lab, Tokyo, Japan  
Control of GPS and Reception of GPS Telemetry  
Data to and from JPL



**1 Meter OPTICAL COMM LINK**



**X-BAND DOWNLINK TO GOLD'S FORM**



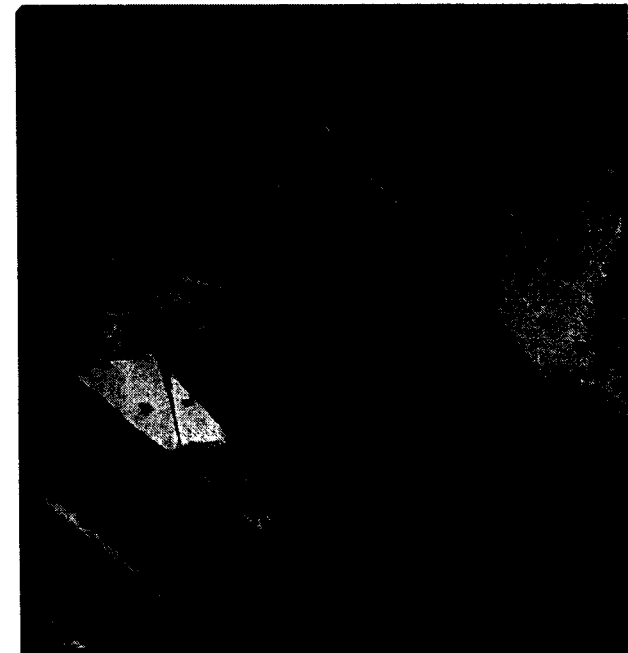
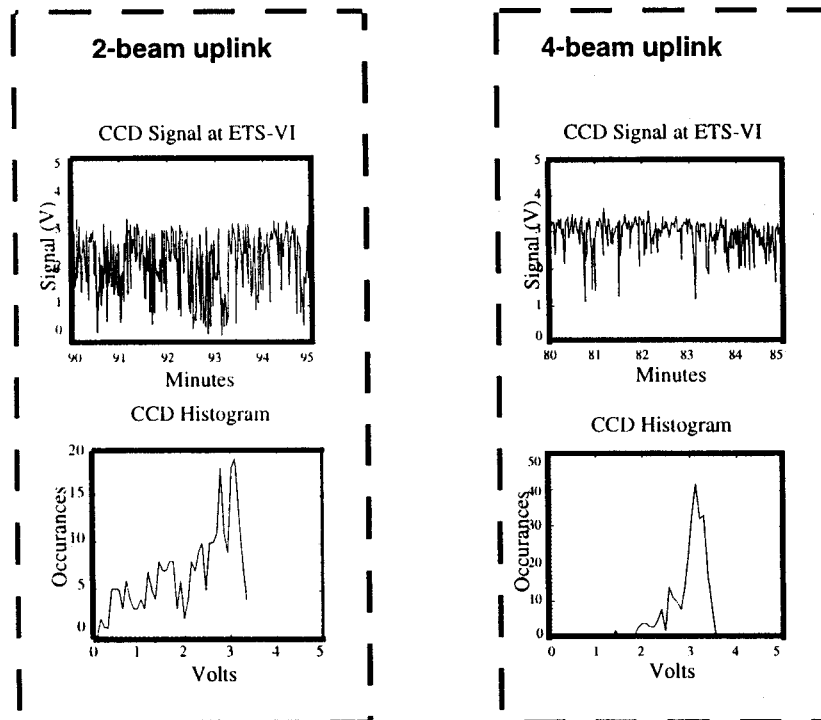

OGS 27 Ground Station  
At Table Mountain  
and the JPL  
Ground Station  
at Goldstone CA

Conducted from November 1995 through May 1996, the Ground-to-Orbit Laser-communication Demonstration (GOLD) was the first demonstration of bidirectional ground-to-space optical communications from JPL's Table Mountain Facility in Wrightwood, California, to the ETS-VI satellite 38,000 km away. The bidirectional data rate was 1 Mbps.




# Multiple-beam Ground-to-Space Link

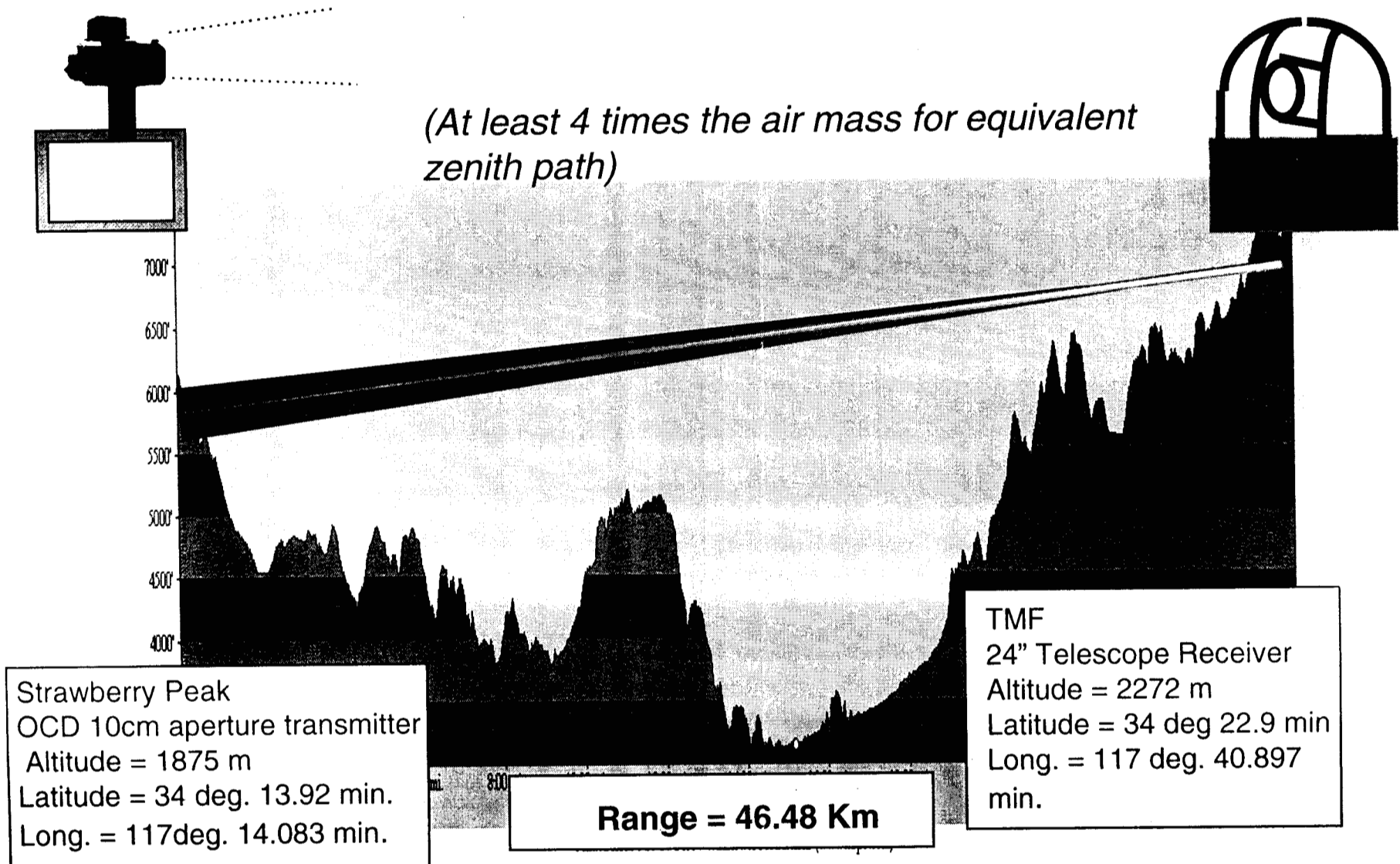
- Multiple-beam transmission mitigates effects of scintillation-induced fades on ground-to space link



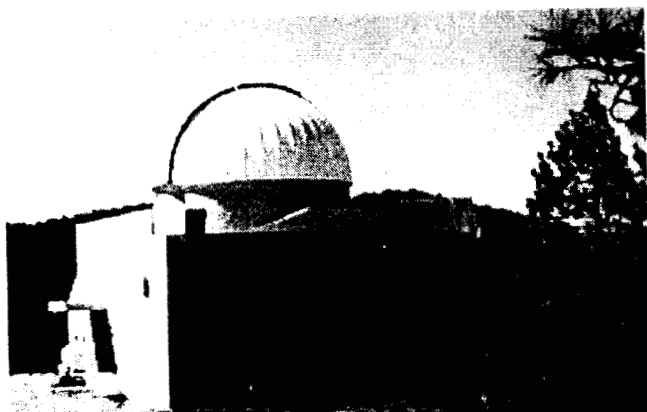
**Four-beam uplink to ETS-VI spacecraft**



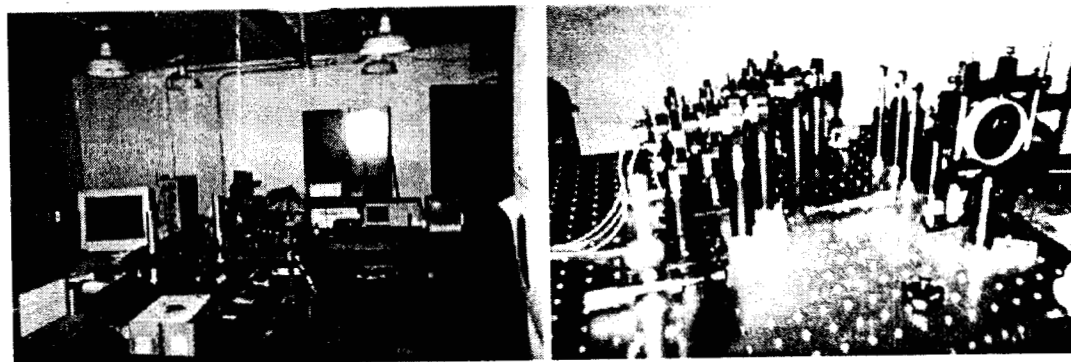
# Horizontal Path Tests of Optical Com Demonstrator



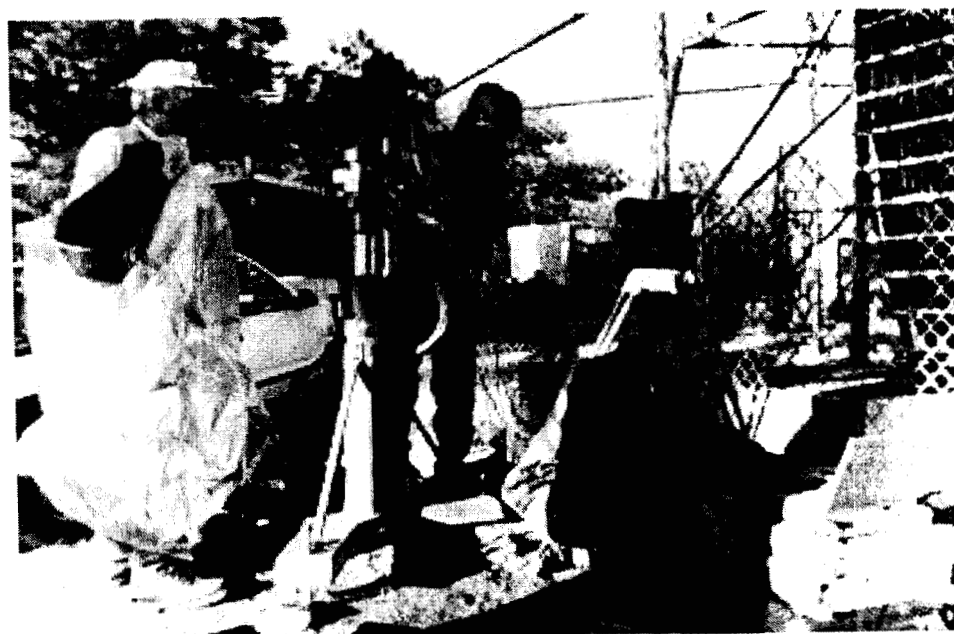
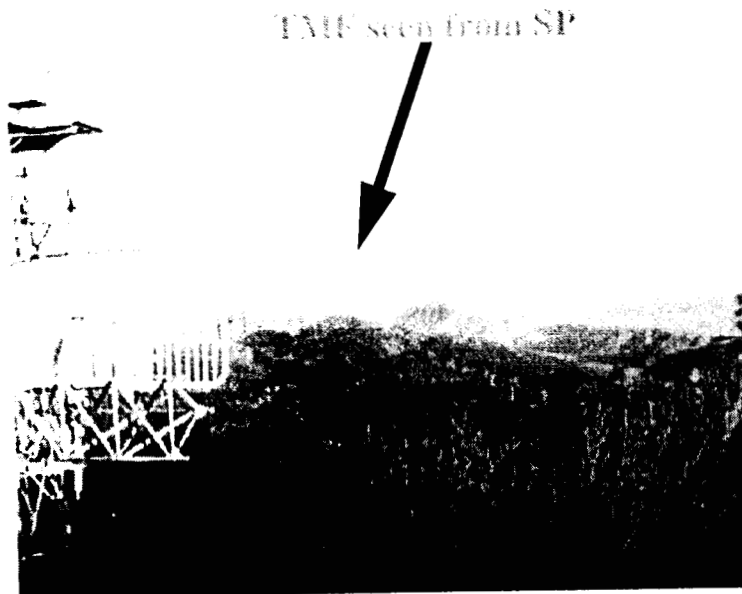
# Strawberry Peak and TMF Stations



TMF 24" telescope dome used as receiver



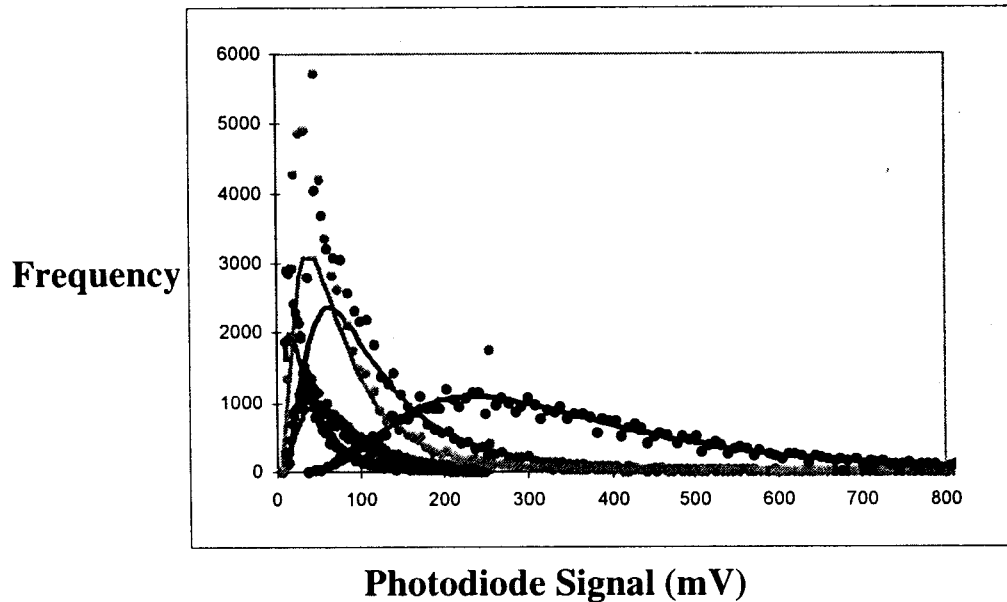
Coude Room Optical Assembly



OCD set up at Strawberry Peak

# Multi-Beam Scintillation Measurements

- *Scintillation index of N beams should decrease as 1/N*  
*(N=4 for demo)*



Measured standard deviations of  
intensity (Normalized)

<u>Single Beams</u>	Beam 1	0.50
	Beam 2	0.82
	Beam 3	0.68
	Beam 4	0.73

4- Beams

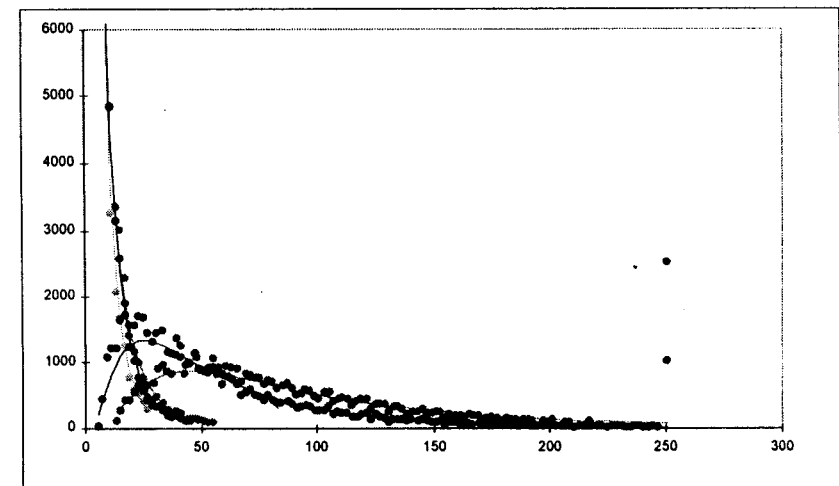
0.22 (0.17 predicted)

Single Beams

Beam 1	1.04
Beam 2	0.76
Beam 3	0.75
Beam 4	0.72

4-Beams

0.34 (0.20 predicted)





# Autonomous Visibility Monitoring Instrumentation at TMF

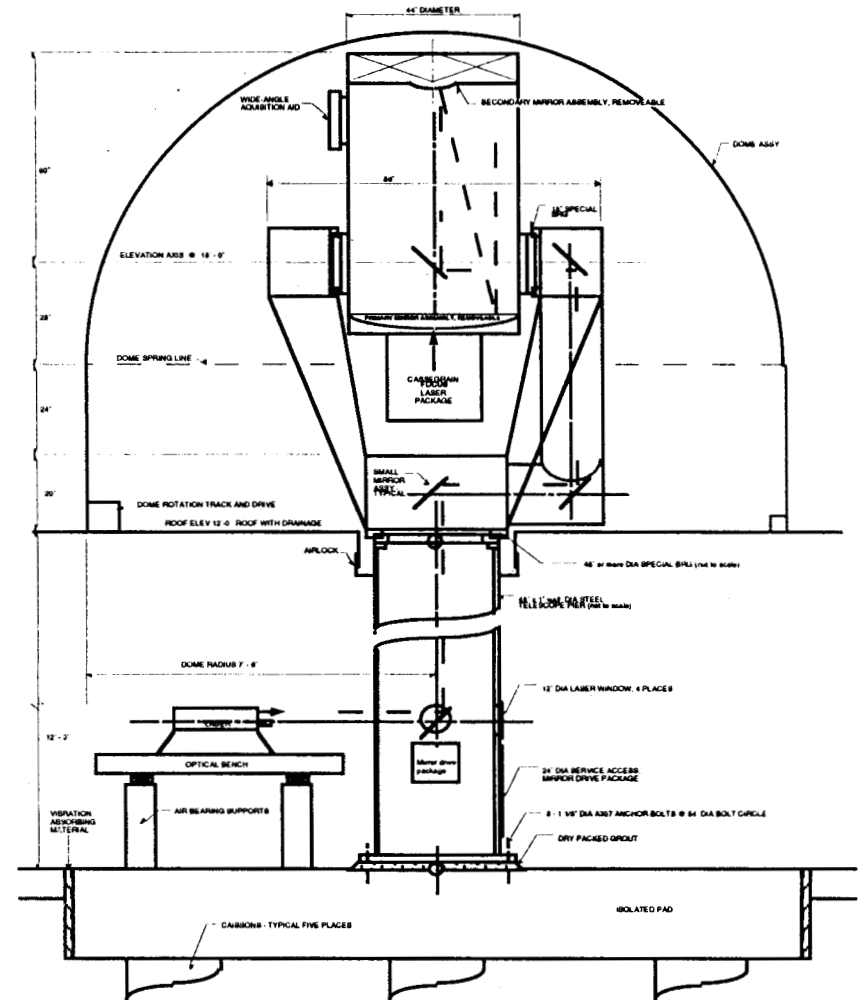
- Visibility monitoring stations at Mt. Lemmon AZ , Goldstone CA and Table Mountain CA autonomously measure atmospheric transmission at visible and near-IR wavelengths



**AVM at TMF**

# Future Optical Com Developments (TMF)

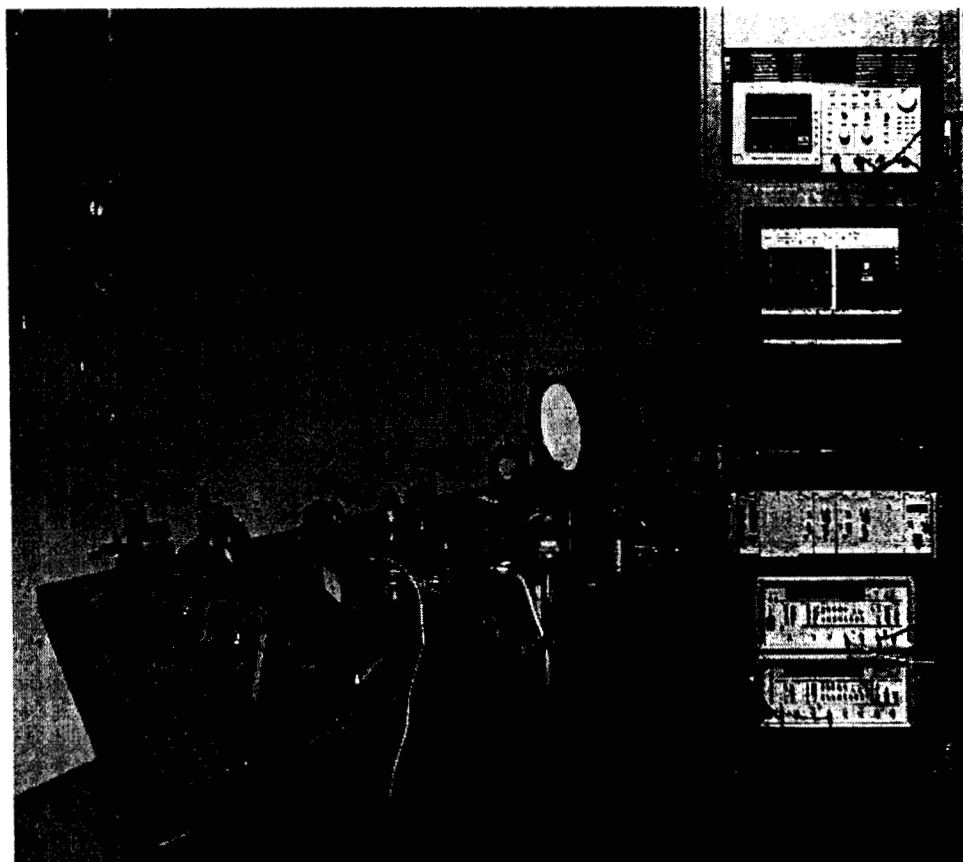
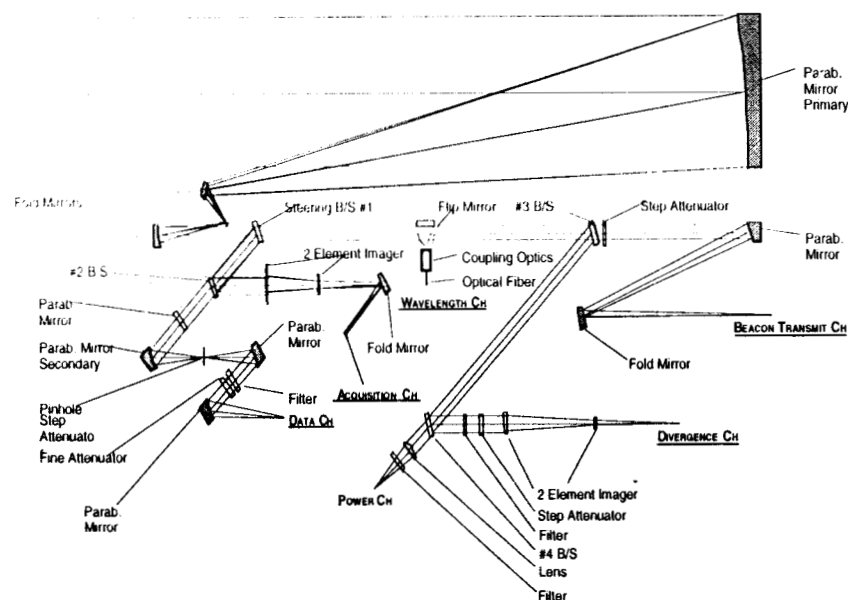
- Optical Communications Telescope Laboratory is a multi-function laboratory with principal focus on optical communications.
- Telescope is R & D terminal designed to support future NASA optical communications research
- Telescope request for proposal was let Feb. '99
  - Contract expected to be et April '99
- Building construction expected to begin May '99



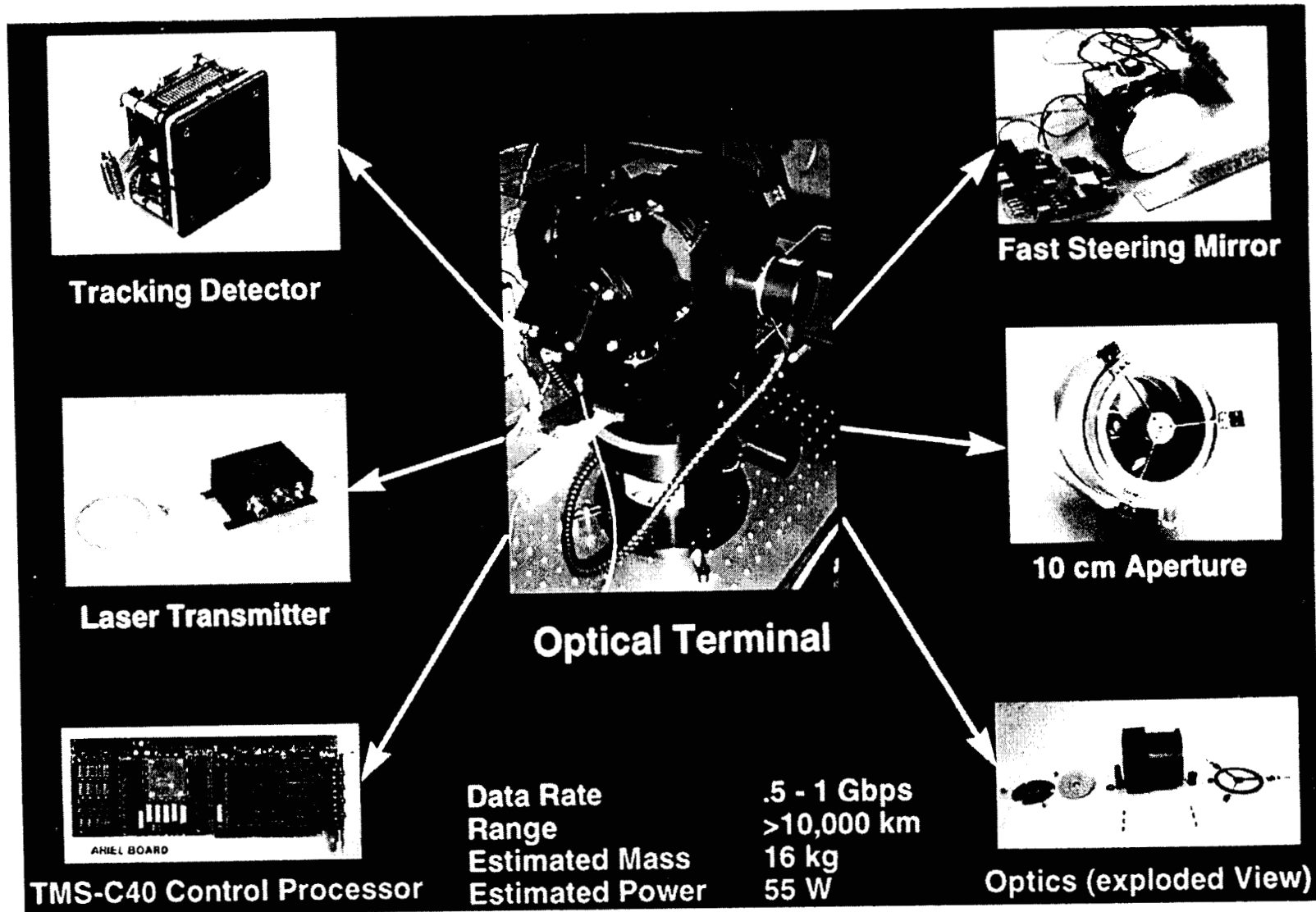
**OCTL telescope, pier and foundation**

# Laser Terminal Evaluation Station

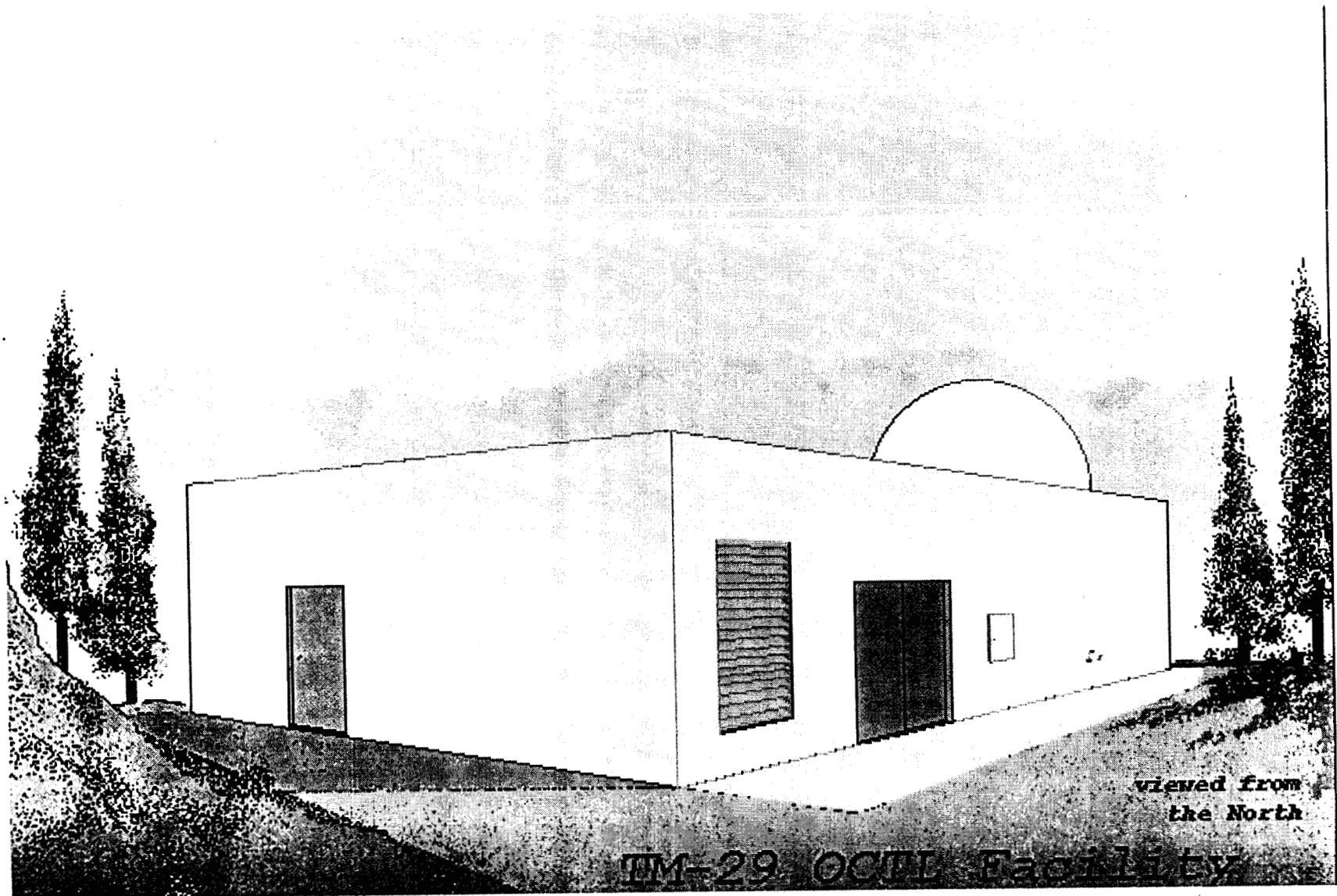
- LTES is a high optical quality instrument that has been used to characterize the performance of STRV-2 and OCD laser communications terminals
  - Measures divergence, acquisition and tracking performance, optical output power, and BERs of Lasercom terminals up to 1.4 Gbps data rates
  - Replacement of appropriate of beamsplitters and detectors allows operating to extend out to  $2\ \mu\text{m}$



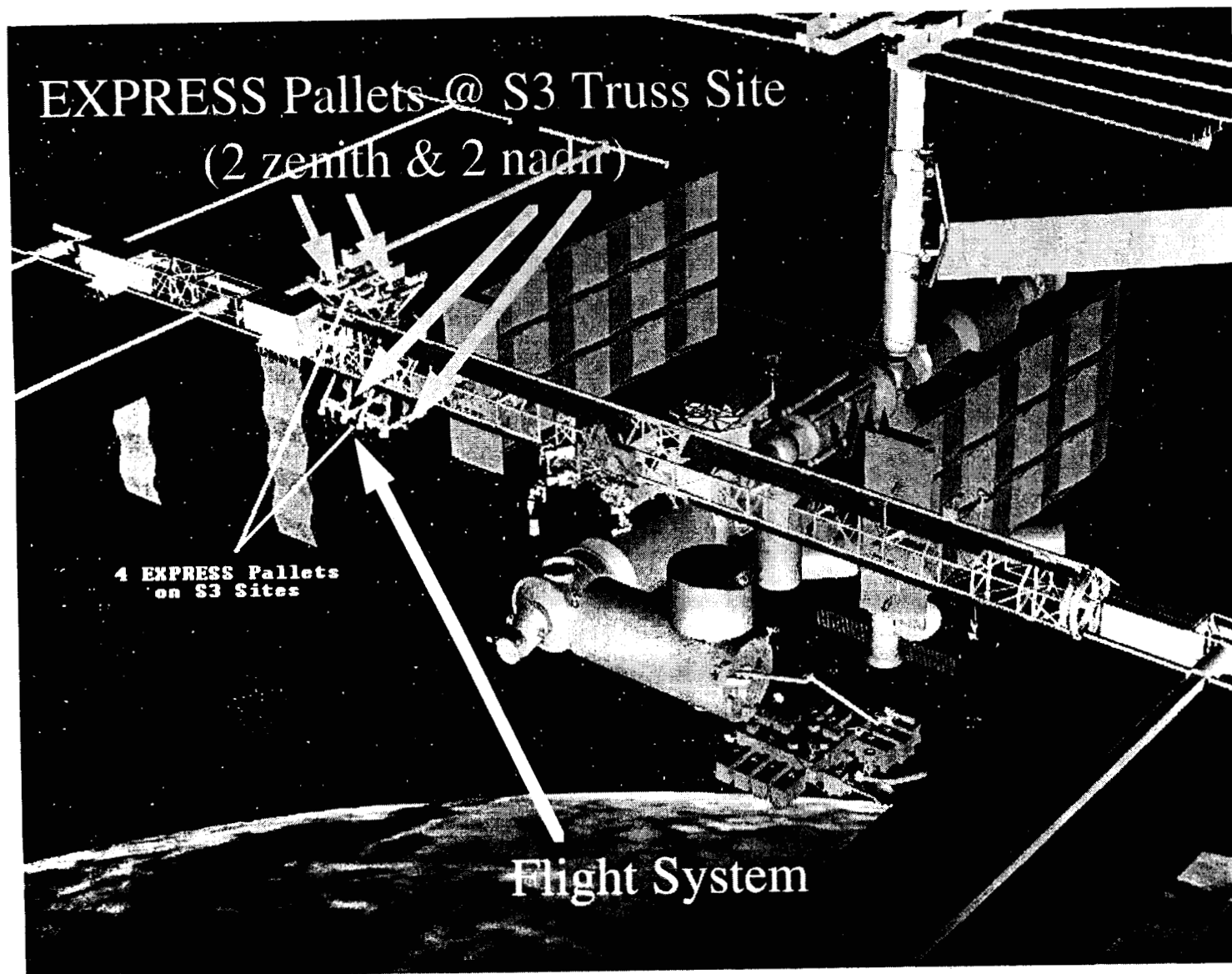
# Optical Communications Demonstrator



# Artist's Concept of OCTL



# International Space Station



- Flight ULS  
10/02
- Flight System  
integrates to a  
nadir-facing  
EXPRESS  
Pallet  
Adapter

# Summary

- **JPL's optical communications program has:**
  - **Demonstrated optical communications to spacecraft at deep space and geostationary ranges**
  - **Demonstrated advantages of multi-beam transmissions in ground-to-ground and ground-to space experiments**
  - **Developed an optical communications terminal that is readily converted from deep space to Earth-orbiting applications**
  - **Developed laboratory and field capabilities to evaluate optical communications terminal performance**
- **The program is supporting:**
  - **Construction of an optical communications laboratory at its TMF to support future demonstrations (ground-to-ground to space-to-ground)**
  - **Continuing development of visibility models from statistics acquired from autonomous monitoring stations in the southwestern US.**
  - **Development of optical com terminal for space-to-ground link form ISS in 2002**